MASSACHUSETTS CLEAN ENERGY CENTER

Waltham Healthcare Center

This case study is part of the MassCEC BETA: Project Planning program, committed to helping a representative selection of commercial building types in Massachusetts reach net zero emissions by 2050.

Building type	Healthcare
Location	Waltham
Year built	1992 and 1996 (two buildings)
Stories	7
Square footage	380,000
Energy use intensity (EUI)*	143 kBtu/sf/yr
Carbon emission intensity (CEI)*	9.6 CO2e kg/sf/yr
Decarbonization goals	Utility cost savings, regulatory compliance

The facility consists of two buildings renovated in 2019, including lighting upgrades. In 2024, 10 of 12 rooftop units (RTUs) were replaced and consolidated into nine new units with no heat recovery. Some fan-powered boxes (FPBs) were converted from electric resistance to natural gas over the past decade. The original enclosure has not undergone thermal improvements.

Existing Conditions

	Walls	Roof	Windows
Enclosure	Fair	Fair	Fair
Heating	Packaged RTU systems (gas furnace). Fan power boxes with zone reheat (a mix of electric resistance and hot water sourced from existing gas boiler). No heat recovery		
Cooling	Direct expansion (DX) cooling		
Ventilation	Ventilation is supplied through RTUs		
Hot water	450-gal tank, gas domestic hot water (DHW) heating		
Lighting	LED lighting throughout (remaining fluorescent in some areas)		
Controls	Limited temperature setbacks. No demand control ventilation (DCV)		
Other	Process load: steam generator for operating room dehumidification (not included as part of the decarbonization assessment)		
Renewable energy	Existing solar PV system estimated at ~490kW located on adjacent parking garage (under power purchase agreement (PPA)). The facility owner procures off-site carbon offsets across its portfolio		

*EUI represents the annual energy usage of the building divided by the total area. CEI is the amount of greenhouse gas (GHG) emissions divided by the total area.

Key Challenges & Solutions

Recent HVAC systems upgrades

Install heat pump RTUs in the near term and replace the remaining two units by 2030 (prior to end-of-life). Newly installed gas units will be electrified at end-of-life in 2040

Need to limit occupant disruption and reduce technology risk in a critical environment

Phase work and temporarily supplement essential systems to test and verify new equipment before upgrading critical spaces

New primary heating system recently installed

Prioritize enclosure air sealing and weatherproofing to reduce heating loads, lower utility costs, and improve occupant comfort until a full enclosure replacement is needed

Core Decarbonization Strategy

- Packaged gas RTUs create an opportunity for cost effective heat pump RTU replacements
- New equipment is staged to align with HVAC systems' end-of-life while managing upfront costs
- Replacing the gas boiler with an air-to-water heat pump (AWHP) supports the existing fan power boxes' hydronic reheating while minimizing intrusive interior renovations

Retrofit Measures and Energy Impacts

Measures

Energy Efficiency & Load Reduction

Foundational Efficiency and Load Reduction:
- Lighting system controls upgrade
- Enclosure air sealing
- DCV system

Advanced Load Reduction:
- Roof replacement
- Window replacement

System Electrification

Electrification Enablers:
- Existing electrical service capacity to be evaluated
- Thermal stress capacity test of FPBs/variable air volume (VAV) systems for low-temperature hot water performance

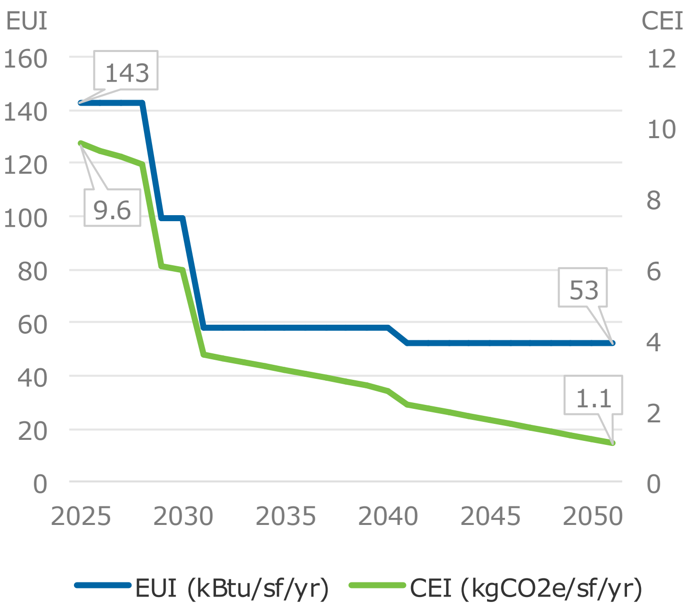
System Electrification:
- Heat pump RTUs with heat recovery
- AWHP for FPB reheat
- Heat pump DHW system

Renewable Energy

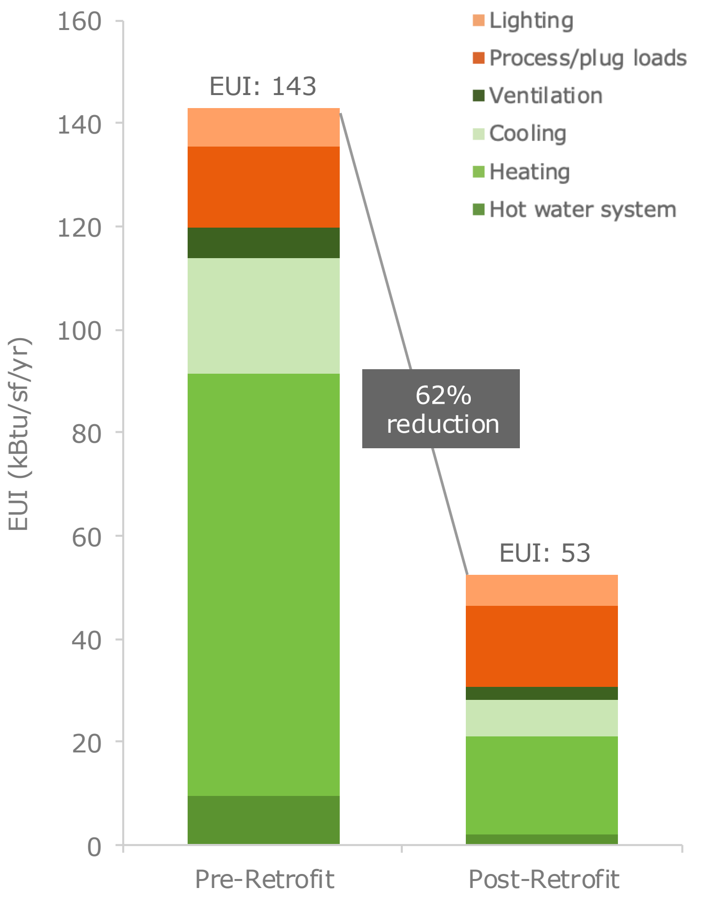
Solar:
- Existing solar PV array ~490kW system under PPA located on adjacent parking garage

Performance Targets

The decarbonization approach prioritizes short-term energy efficiency and load reduction measures and end-of-life replacement of major HVAC system components to all-electric heat pump RTUs by 2040. The recommended measures result in a 62% EUI reduction and up to 77% GHG reduction. These efforts would yield the following results over time:



Annual Energy Use Impacts*



*The annual energy use impacts graphic illustrates an EUI before and after once all recommended measures are implemented, except for any renewable energy. The CEI and EUI shown in the performance targets account for the added benefits of renewable energy.

Project Planning

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The graphic below presents a decarbonization pathway, organizing measures into bundled actions that are best implemented together. The expected cumulative carbon reduction potential from each bundle is noted on the right. The strategy to reach zero GHG emissions by 2050 focuses on maximizing energy efficiency, electrifying on-site combustion systems within a cleaning grid, and cost-effective on-site renewables. Key considerations or triggers are listed along a timeline to support informed decision-making, with bolded dates indicating recommended implementation years.

Triggers

2028: Foundational energy efficiency improvements are not time dependent and may be implemented prior to electrification of systems to support energy costs savings

A thermal stress test is recommended as part of electrification planning prior to systems electrification

2030: End of service life for two RTUs

2030-2035: Evaluate electrical service upgrades by 2030 to support heating electrification, and size infrastructure to accommodate full electrification by 2040

2040: End of service life for nine remaining RTUs

Under the PPA, solar RECs and associated GHG reductions are not retained by the facility. If the system were owner-purchased, an additional ~11.8% GHG reduction could be claimed

Order of Implementation

Cumulative Carbon Reduction Potential*

Lighting System Controls Upgrade

DCV System

Air Infiltration Reduction
Perform testing and air sealing to enclosure

Existing HVAC Infrastructure
Evaluate FPB/VAVs existing heating performance with thermal stress test to verify if existing infrastructure allows for low-temperature hot water performance

36%

Heat Pump Packaged RTUs and AWHP
Replace the two existing RTUs with heat pump RTUs, including heat recovery. Add AWHP to supplement gas boiler

DHW Electrification
Install heat pump DHW heater

Roof Replacement
Increase insulation level on roof

Window Replacement
Install new triple-glazed windows

Existing Electrical Infrastructure
Evaluate existing electrical infrastructure capacity for electrification of heating

62%

Heat Pump Packaged RTUs
Replace the nine existing RTUs with heat pump RTUs, including heat recovery

Solar PV System
Maintaining existing solar PV under PPA contract would account for additional 11.8% GHG reduction

77%

Zero on-site fossil fuel combustion
(With the exception of any backup power)

*GHG calculations are based on BERDO Version 2.3 emissions factors. Full decarbonization is dependent on statewide renewable energy adoption. GHG calculations include direct onsite combustion (Scope 1) and purchased electricity (Scope 2). For any renewable energy measures included in this plan, it is assumed that the owner will retain the Renewable Energy Credits (RECs) to claim the GHG reduction for reporting.

Cost Analysis

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Annual Utility Impacts

Measure description	Changes in annual utility costs		
	Electricity	Fossil fuel	Net total changes
Lighting	($27,998)	-	($27,998)
Process/plug loads	$28,865	-	$28,865
Ventilation	($75,194)	-	($75,194)
Cooling	($396,481)	-	($396,481)
Heating	($478,752)	($248,236)	($726,288)
Hot water system	$57,388	($53,390)	$3,998
Total from recommended measures	**($892,172)**	**($301,626)**	**($1,193,798)**
Renewable energy	Existing solar PV under PPA (creates an estimated $87,000/yr of utility savings)		

Existing renewable energy PPA PV system is not included in utility bill cost calculations. It currently applies to both pre-retrofit and post-retrofit loads and is estimated at $87,000 utility savings annually. Additional renewable energy is limited for this site.

Lifecycle Costs*

Realizing the full value of decarbonization requires a long-term outlook that weighs upfront investments, operating costs, and financial incentives. BETA assessments identify the retrofit pathway that most effectively reduces emissions, maintains comfort, and improves performance relative to upgrades an owner would already make (the business-as-usual (BAU) scenario). This comparison highlights long-term avoided costs and risks, as well as opportunities—such as incentives—that support pursuing the optimized pathway.

Costs	BAU retrofit	Optimized decarbonization pathway	
Base building and envelope costs	$7,297,000	$1,276,000	Foundational efficiency and load reduction
		$7,297,000	Advanced load reduction
Mechanical costs	$6,599,000	$1,900,000	Electrification enablers
		$10,877,000	System electrification
Renewable energy costs	$0	$0	Renewable energy
Soft costs	$3,474,000	$5,338,000	
Total upfront costs	**$17,370,000**	**$26,688,000**	
Utility incentive opportunities	$0	$514,000	
25-year total accrued utility costs	$106,077,000	$66,053,000	
25-year accrued total operating costs	$112,306,000	$70,122,000	
25-year LCCA	**$129,676,000**	**$97,324,000**	

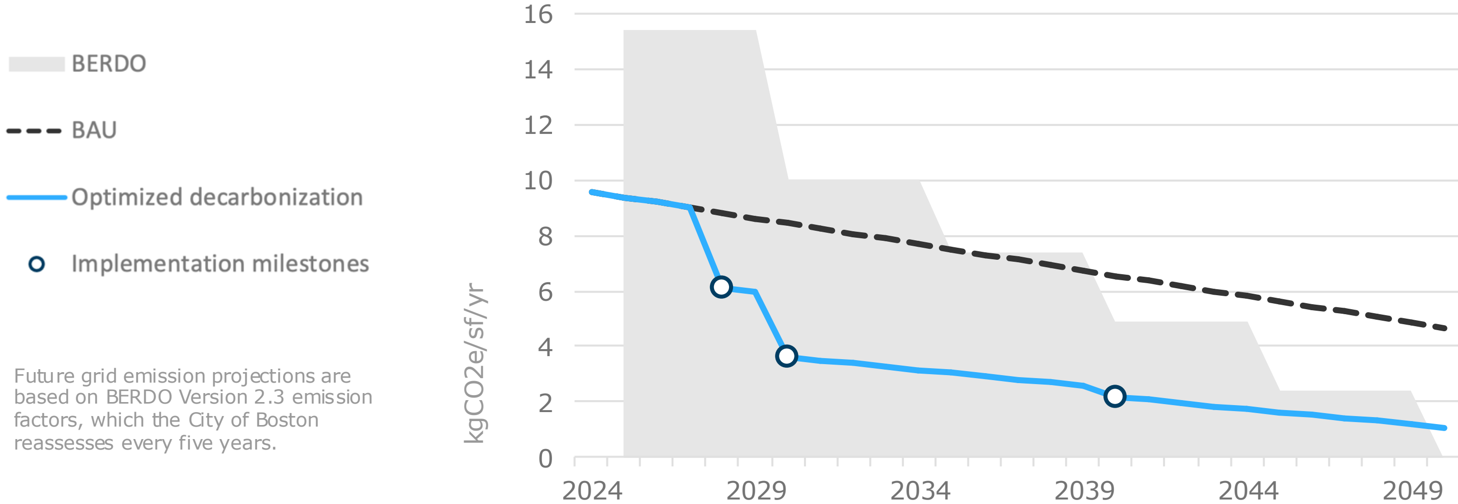
BAU scope:

- Replacement of two RTUs and DHW
- Roof and window replacement
- Boiler and nine RTU replacements
- Electrification ready infrastructure based on code requirements

*All cost and incentive values are estimated based on industry data and rounded to the nearest $1,000. All incentives values are based on currently available programs and are subject to change over time. Forecasted operating costs include utility costs, maintenance costs, and noncompliance fees if relevant. Utility and maintenance costs reflect a 3% annual escalation rate. The BAU approach assumes necessary repairs and replacements that meet code compliance. In this case study, BAU represents the conventional gas or code-compliant versions of the decarbonization measures listed.

Emissions Goals and Benchmarking

Boston's Building Emissions Reduction and Disclosure Ordinance (BERDO) applies to large existing buildings in the city and, outside Boston, serves as a useful benchmark for owners to proactively align upgrades with statewide goals. As Massachusetts targets net-zero emissions by 2050, similar policies may be adopted statewide. Achieving "zero" depends on the pace of statewide renewable energy adoption, with any remaining gaps addressed through RECs or clean electricity aggregation programs.



Future grid emission projections are based on BERDO Version 2.3 emission factors, which the City of Boston reassesses every five years.

Resiliency Considerations

The facility is located just outside current FEMA flood zones but remains vulnerable to increasingly intense rainfall events. A climate vulnerability assessment is recommended, including evaluation of floodproofing measures for ground-level equipment such as electrical service, generators, and other energy systems. Existing solar generation offsets approximately 7% of annual energy use, with limited opportunity for expansion. Battery storage is not currently feasible based on the owner's recent assessment. The owner also noted grid reliability concerns that may increase electrification risk for heating systems.

Next Steps and Best Practices

There are many potential strategies to reduce the operational GHG emissions of buildings. As a starting point, owners are encouraged to have a solid understanding of base building information, including current energy use, carbon emissions, and long-term property goals through 2050. The data and scoping developed through this assessment can be used by design teams, including architects and engineers, to begin shaping project plans and construction timelines, while also strengthening financing strategies and incentive applications. To move from assessment to action and ensure a clear, strategic path toward decarbonization, the following next steps are recommended.

- [x] Existing building conditions
- [x] Decarbonization assessment
- [ ] Supplemental assessments
    - Thermal stress capacity test
    - Evaluation of existing electrical infrastructure
- [ ] Emergency protocols
- [ ] Assemble project team
- [ ] Structure financing stack